Concrete Engineering and Technology
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Lecture - 35
Measuring permeability in concrete

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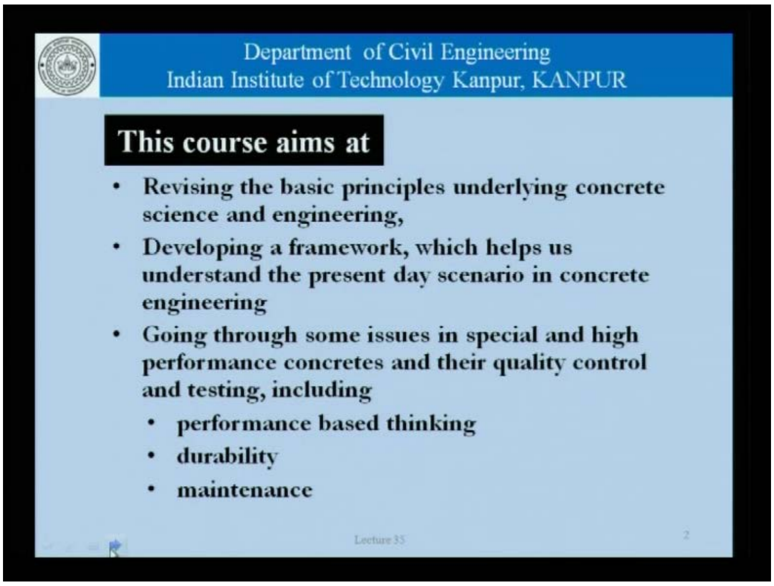

Welcome to another round of discussion on Concrete Engineering and Technology. And this module 6 to revise basic principles underlying concrete science and engineering, develop a framework which helps us understand. The present days scenario in concrete engineering, we developments in admixtures, methods of construction, different materials being used and so on. And going through some of the issues, which are of special relevance, in special high performance concretes, and they quality control and testing, including performance based thinking durability and maintenance.

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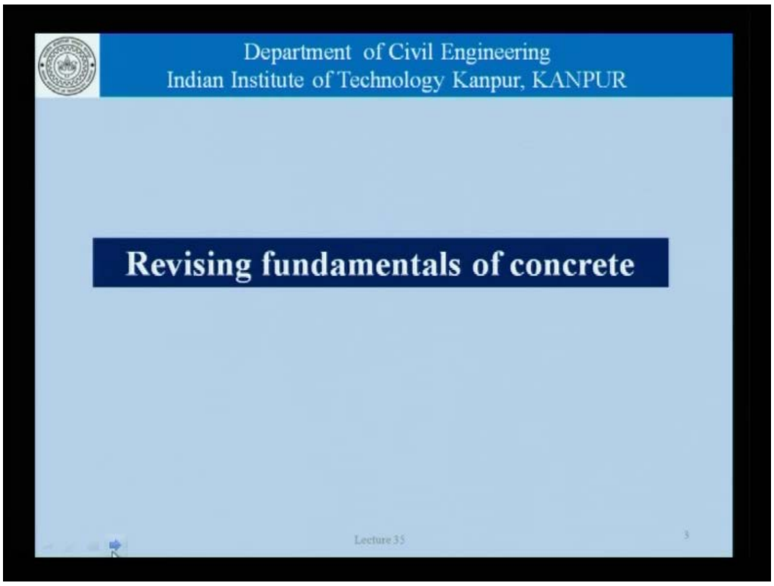

Now, once we are talking about fundamentals of concrete.

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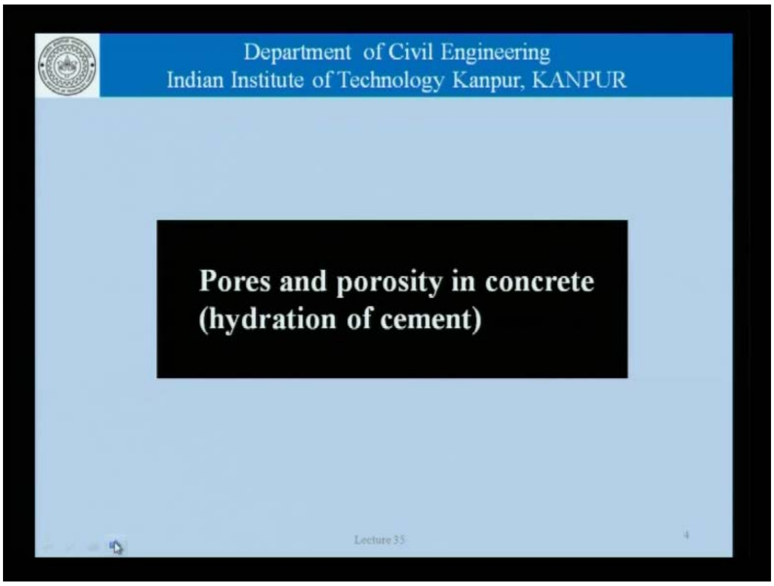

We have talked a little bit about pores and porosity in concrete, arising out of hydration in cement.

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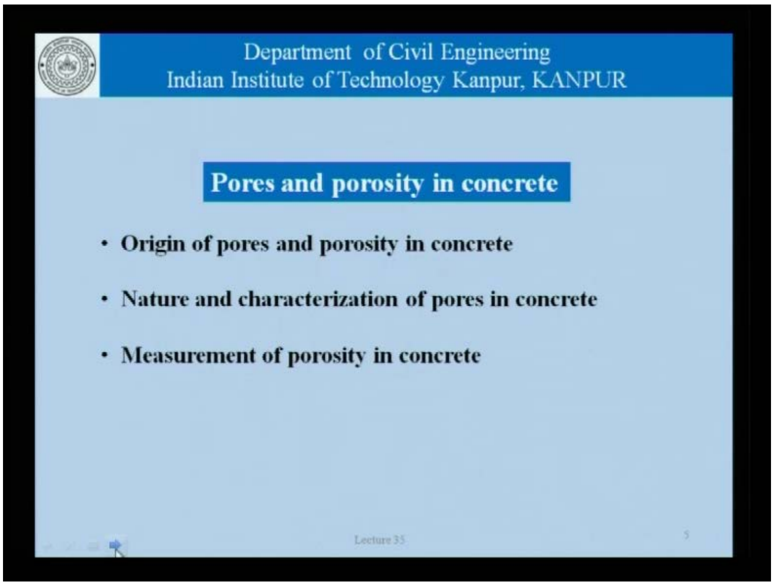

An at that time, we have talked about origin of pores and porosity, we have talked about the nature and characterization of pores, in terms of the total pore volume, the differential pore volumes and so on. And we also talked about measurement of porosity in concrete, using mercury inclusion pores symmetry. Now, of course, mercury inclusion pores symmetry just one of the tools, but we have an idea of the fact that concrete is a pores material, having pores of different sizes and those pores can be measured.

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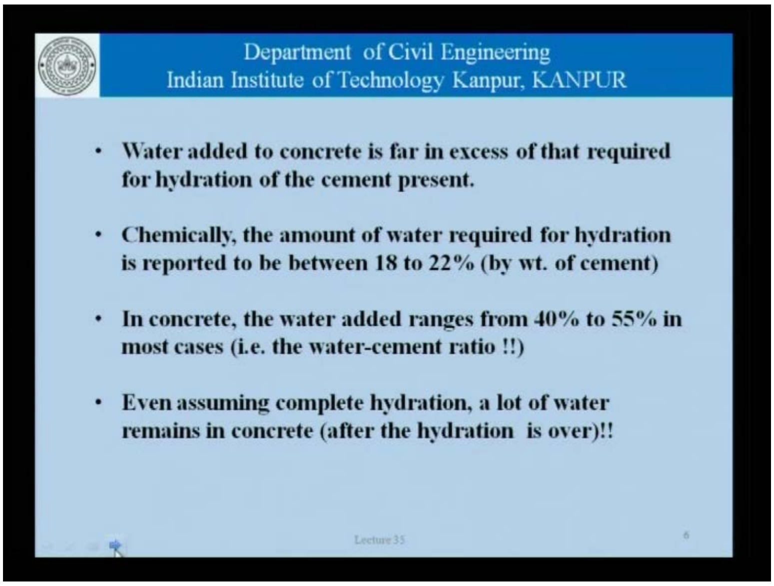

Where those pores come from is primarily on account of water added to concretes, being far in excess of that required for hydration of the cement. Chemically that water being about 18 to 22 23 percent, and the actual water being added being in the range of 40 to 55 percent in most cases. A lot of water does remain behind in concrete after the hydration has taken place.

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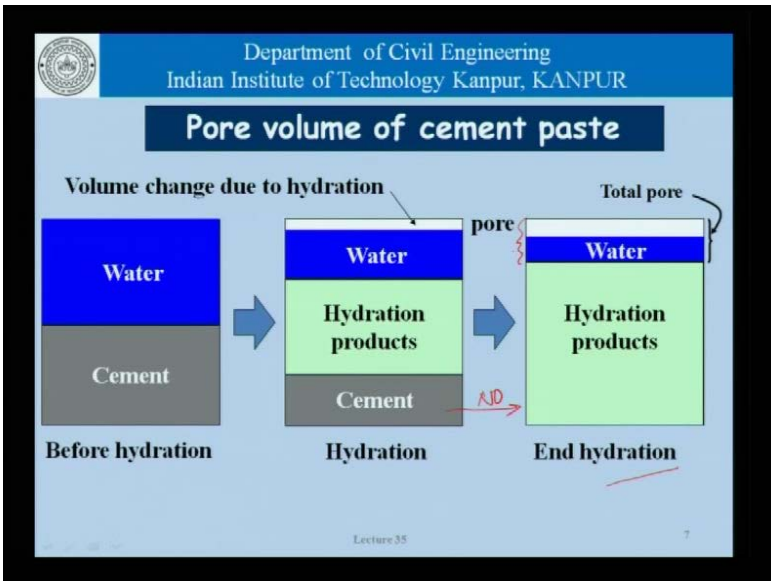

And this is the kind of picture that we showed, showing cement and water before hydration, during hydration and at the end of the hydration process. Where in this particular case we have shown, no cement is remaining and all of the and all the cement has been converted to hydration products. And this is the total amount of pores that are formed within concrete, whether they are saturated with water or not is different story, but yes, this is the amount of space which is available for water to be present. And if water is driven out leaves that are the amount of space, which is left as pores as far as concrete is concerned.

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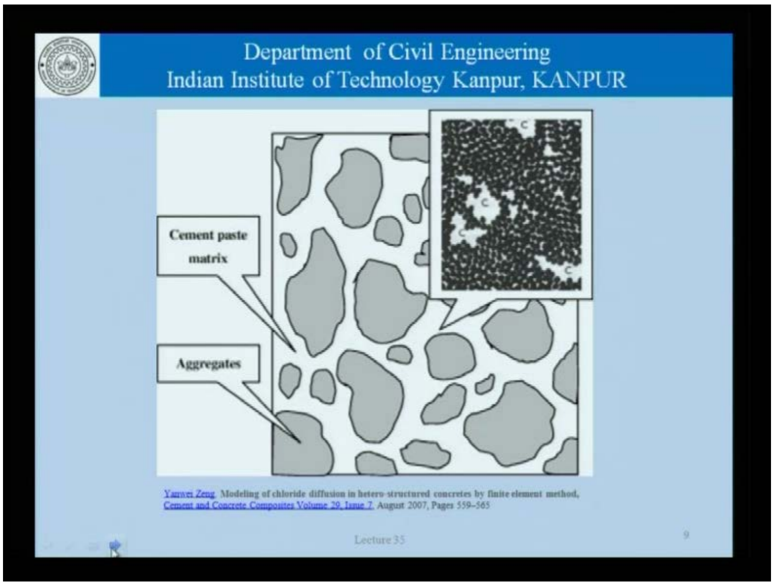

We had looked at this picture, which is representation of aggregates surrounded by cement piece matrix and this matrix having pores.

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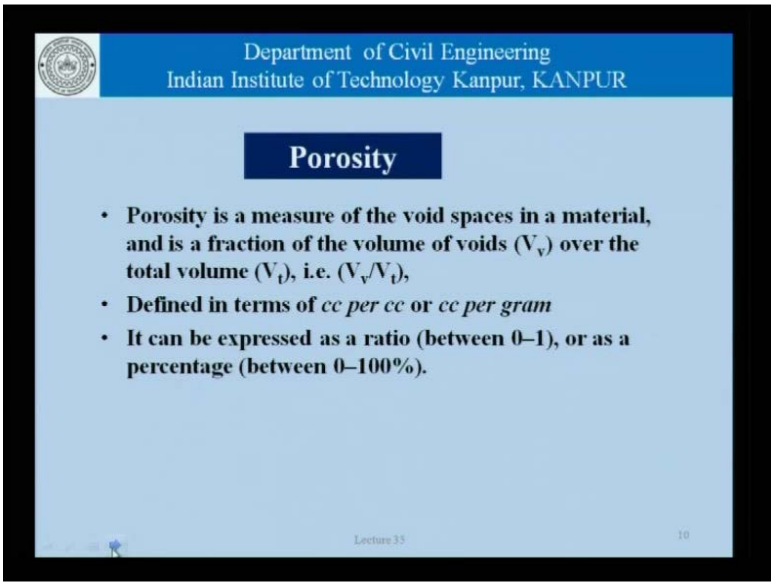

And then that seen a re-iteration of the definition of porosity, which is nothing but a measure of the void space in a material that is, it is a fraction of the volume of voids to the total volume. And can be expressed in terms of cc per cc or cc per gram of the material, and as a percentage and so on.

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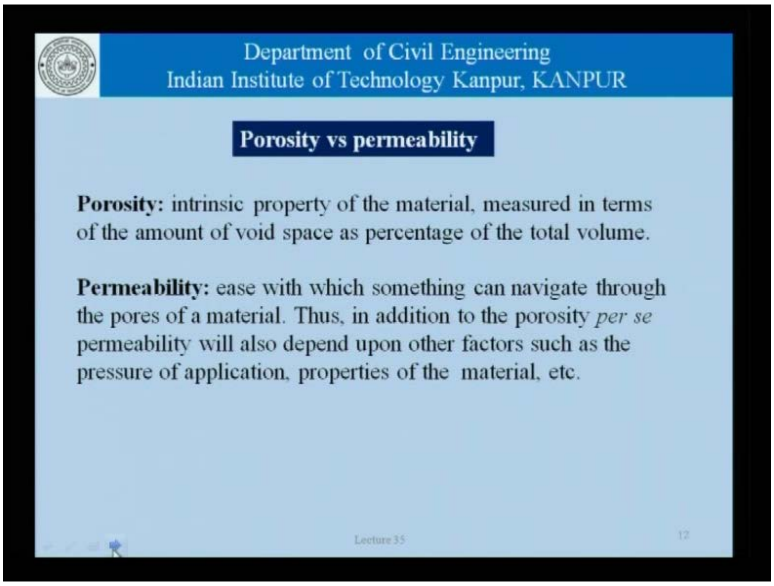

The question that we now a start to deal with is that of porosity verses permeability, porosity as we have discussed is the intrinsic property of the material, measure in terms of the amount of void space a percentage of the total volume. So, porosity is in intrinsic property of the material; we can say that, here is a material which is pores which has a certain amount of total voids, we can talk in terms of the pore size distribution of that material, but at the end of it is a property of that material.

Permeability on the other hand is the ease with which something can navigate, through the pores of the material, does in addition to the porosity per say, because obviously a material from outside can navigate through the pore system, only if there are pores. If there is no pore, then we are not talking of any navigation or we are not talking of any permeability. The fact that we are talking of permeability means that, there is a material which has some pores.

But, in addition to the porosity, there are other things that governed the ease with which a material from outside can travel through that material. And these depend on factors such as the pressure of application, properties of the material and so on. So, for example, there is water, in certain cases water can flow very easily, if we are applying pressure it flows more easily. The ease being defined in terms of or measured in terms of for example, the velocity of flow or the quantity of material that flows per unit area, per unit time and so on.

If instead of water we have another fluid, then the permeability changes, if we are talking of gases or air moving through the pores media, the concept of permeability needs to be defined, in terms of gasses permeability. And all this discussion is true even for concrete, water move through concrete, so we can talk in terms of water permeability of concrete, gasses, such as carbon dioxide, oxygen.

They move through concrete, they enter concrete if it is dry, therefore the concepts of gasses diffusion in concrete is equally evaluate; there is ionic diffusion, chlorides from outside for example, in a marine environment they move into the concrete pores. So, we have ionic diffusion, the ionic permeability, all these concepts of diffusion in permeability are applicable as far as concrete is concerned is well. We have talked about measurement of porosity, and today the discussion would focus on permeability.

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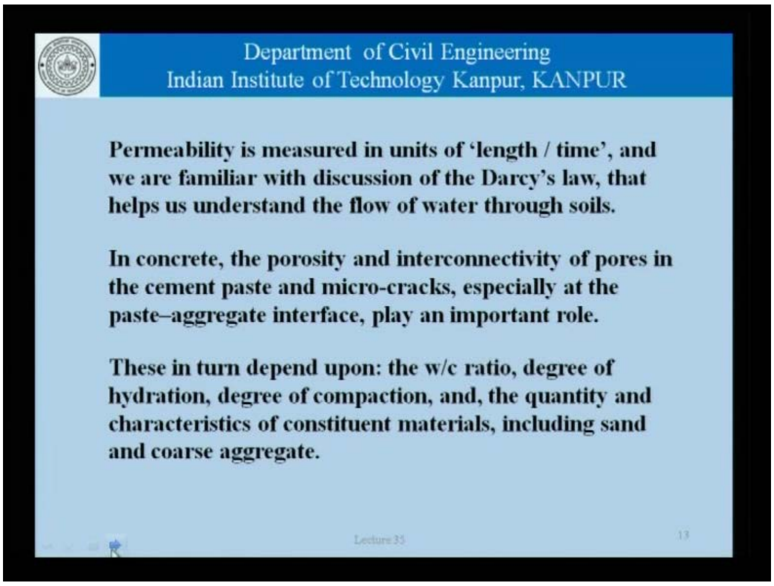

Permeability is measured in units of length per time, we talk of centimeter per second or meter per second, and we are familiar with the discussion of Darcy's law that helps of understand, the flow of water through soils. In concrete the porosity and interconnectivity of pores and cement paste and micro cracks, especially at the paste aggregate interface place a very important role. We talked about this, when we are talking about porosity, these in term that is the porosity and the inter connectivity depend upon parameter.

Such as, the water cement ratio, the degree of hydration, degree of compaction and the quantity, and characteristics of the constituent materials that is cement, sand and so on.

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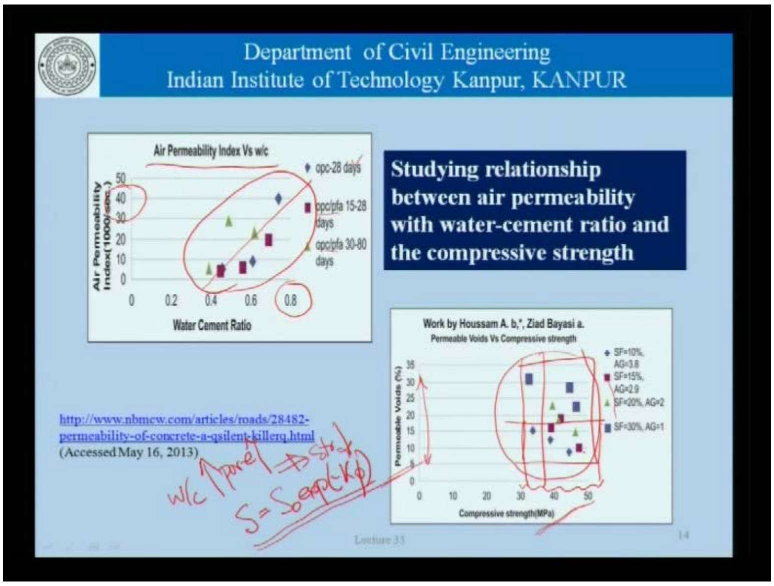

Before we get started with our discussion on permeability, let us look at these two graphs which are the result of an experimental study, which talks of air permeability index, so there is something called in air permeability index. If concrete has pores there is a thought at least that we can understand, that yes if it has pores air will be able to permeate the through those pores. And if we are able to have a test which will measure the air permeability of a concrete, that should be somehow related to the water cement ratio of that concrete, because that really determines the porosity of the concrete.

So, if you look at these points that have been obtained here, we see that there is a lot of scatter, but it the end of it the basic trend that as the water cement ratio is higher, the air permeability indexes higher that does not seem to be violated except that. Of course, depending on the age, and the mix of the concrete and so on, those numbers actually could be different. What is interesting is this graph here, if we look at a plot of compressive strength verses permeable voids, and if we look at this range here, in the range of let us a 30 to 50 MPA of compressive strength of concrete.

The permeable voids percentage varies within a failure large range, what this tells us is that even though, we say that the strength is related to the water cement ratio. And we put forward in argument which selves, that if the water cement ratio increases, the total pores space increases and therefore, the and therefore, they strength goes down, because this strength is related to the pore spaces through an equation of this nature. All this understanding becomes very suspect, because we have evidence that they amount of permeable pores varies quite a lot at a given water cement ratio, or for the same permeable pores, there is strength range is fairly large.

What this tells us at the end of the day is that, if we are doing performance based thinking, then permeability needs to be considered at least for the time being; all most independent criteria for evaluating concrete. Most of our thought process, till date is governed by the fact that concrete is characterized by a principle parameter called compressive strength. And so long as compressive strength is under controlled, we have we have a concrete which needs compressive strength requirements all is well, what this kind of a diagram shows us, is that as far as durable is concerned.

Because, durability is primarily related to the movement of deleterious ions through the pore structure of concrete, as far as durability is concerned, we perhaps need to establish permeability as in independent criteria for characterizing, the performance of a concrete. We can talk of measurement of permeability as a parameter for quality control, that what we talked about just now when we said that well, permeability should be used or can be used as in independent criteria for establishing, and characterizing concrete mixes.

Or there can be a situation, where we are talking about measuring is a two permeability as part of non-destructive testing and evaluation of a structure. In addition to normal test which give us results in terms of compressive strength, ultrasonic pulse velocity, cracking and so on. We can talking in terms of measurement, we can talk in terms of measuring permeability of concrete in C 2 in the structure.

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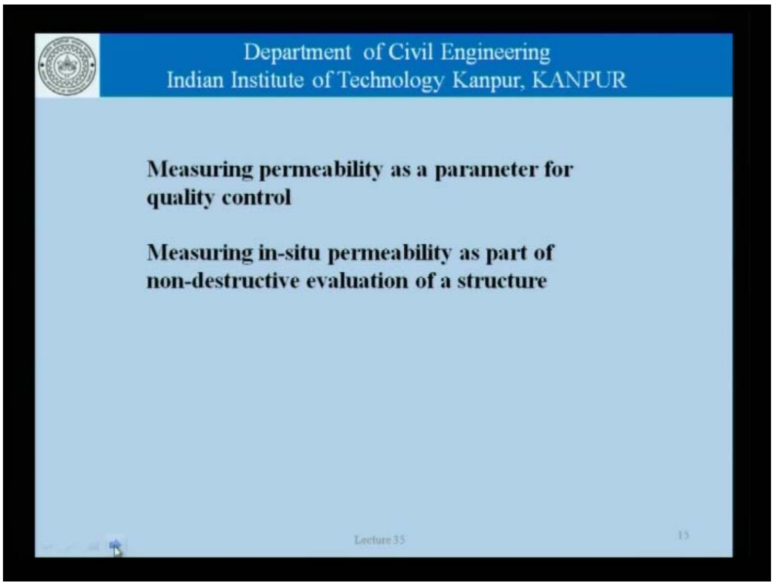

Now, out of these two the discussion today, would focus on measuring permeability as a parameter for a quality control, that is we will be primarily talking about some tests, which have been proposed, and developed in the last say 20, 25, 30 years. And establish permeability as a characteristic of concrete, independent of compressive strength.

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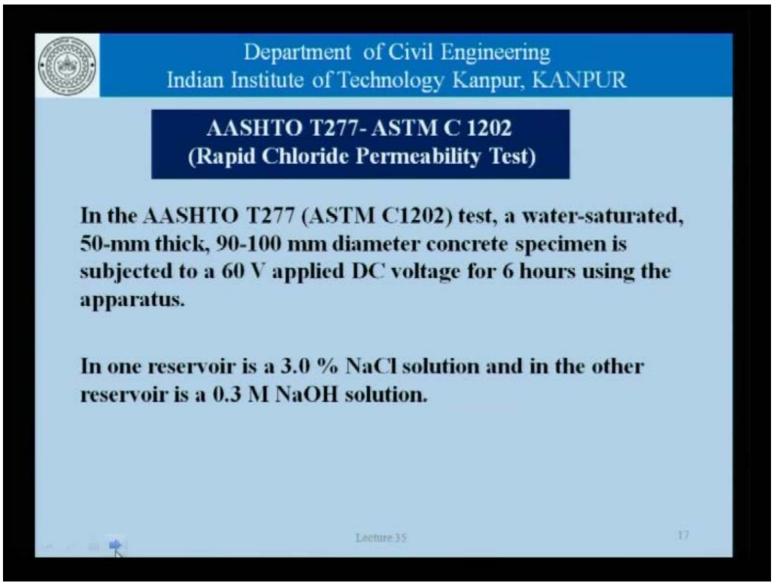

One of the tests that comes to mind in this contexts, is the AASHTO, American association for state an high way transport officers, there test standard quality T277 or the ASTM is C1202, which is a rapid chloride permeability test. Now, this as the name suggest is the method for measuring the chloride permeability of concrete. The test basically consist of testing, a water saturated 50 mm thick, 90 to 100 mm diameter concrete specimen, subjected to 60 volts of applied DC voltage, for 6 hours using in a operators, especially design for the purpose.

One reservoir that is on one side we have a reservoir which has 3 percent sodium chloride solution, and in the other reservoir we have 0.3 mm, any other solution. Now, chloride permeability is one of the most important parameters that an engineer whose concerned with durability of concrete in marine environment, or durability of concrete, on account of likely corrosion of reinforcement, due to chloride (( )) is concerned about. So, we want to establish how soon, or what will be the level of chloride permeability in concrete, and this one of the test.

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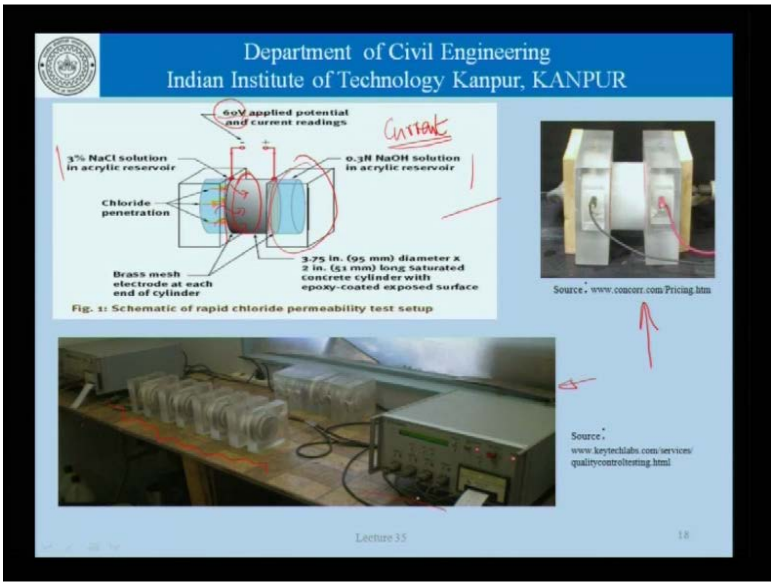

These picture here, they show the test method as is actually used, this here is the test set up as is used, and this is actually a schematic representation, this is the concrete disk. And we apply a voltage of 60 volts across the two faces of concrete; one face of the concrete is an contact with 0.3 and sodium hydroxide solution, and the other face contact with the 3 percent sodium chloride solution.

And what we have really try to do is to induce the chlorides to move through the concrete, except that the measurement is not in terms of movement of chlorides, but it is the current. That flows on account of application of these 60 volts across the two faces, and this current is actually measured over period of 6 hours, and we calculate the total charge that has passed. This picture here is a setup of commercial available setup, where several of such sells can be test together. So, we can put in several specimens of concrete, and run the test in a manner that we can get the current values for each of these channels; and try to get the coulomb values of the charge it has passed for the different specimens.

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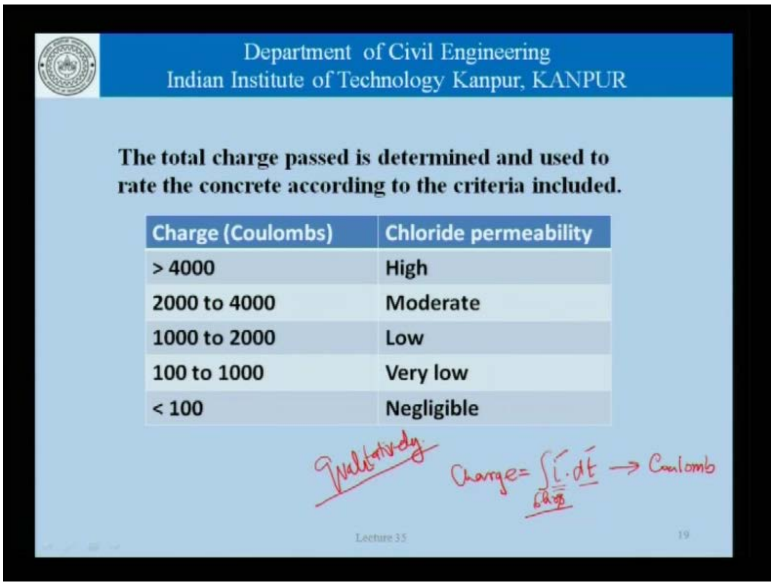

What is really done at the end of it is, the total charge passed is determined, because the charge, the charge that is passed is related to the current it is a only the integral of the current water time for the whole of 6 hours, and this is measured in coulombs. Once we have the i and t data that how much of current is flowing through the two faces or through the concrete, over a period of 6 hours at periodic intervals, we can convert and obtain the total charge that has passed.

And that has been qualitatively related to the permeability of concrete, it is not a quantitative relationship, it is qualitative relationship, and says that if the charge passed is more than 4000 coulombs, the chloride permeability is high. If it is 2000, and if it is between 2000 and 4000, it is moderate if it is between 1000 and 2000 it is low, if it is 100, if it is between 100 and 1000 it is very low, and if it is less than 100 it is negligible.

What a user as for as performance based on though processors concerned could do is the say that well, are you want a concrete to be used and the structure, which has such and such strength as far as structural design is concerned. But, I want the concrete to have not more than moderate chloride and permeability, as determined by the ASTM C1202 test.

So, now we have established an independent criterion for evaluating the concrete or the suitability of a concrete that is going to be use in a structure. A part from the strength criteria which is coming from the structural design, there is a durability criteria which is coming from the point of view of chloride permeability, defined in terms of the rapid chloride permeability test. And a specific number or a specific target is given that it should not be more than moderate.

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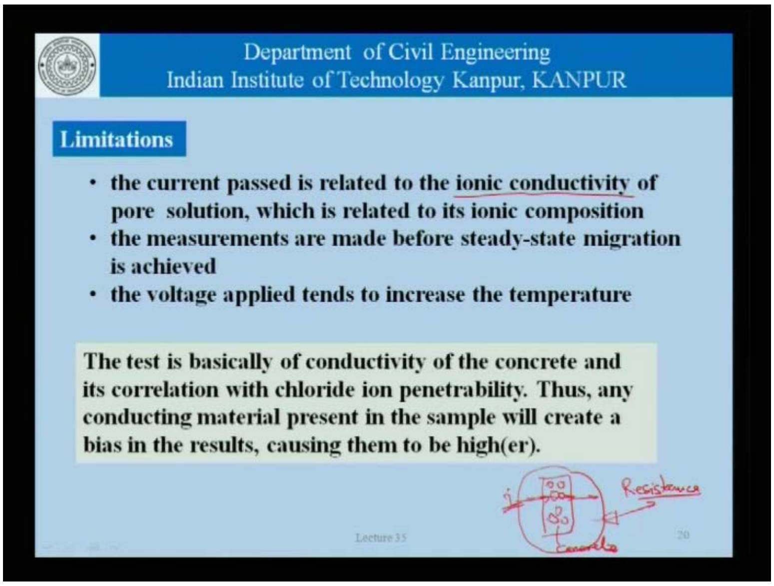

This test obviously has certain limitation; the current past is related to the ionic conductivity of the pore solution, which is related to its ionic composition. What is happening in this test is that at the end of it, this is the concrete piece or the specimen, and we are applying a charge, which causes this current to flow through the concrete. So, even though we are trying to measure the current, what we are effectively trying to do is to determine the resistance of the concrete.

And how it changes over time, because once the resistance changes the current also changes. Now, once this is the mechanics of the test what we are really concerned about is, that the ionic composition of the pore solution, what kind of ions are present that would have some bearing on the ease with which the current can flow through this concrete. The measurements are made before study state migration is achieved, so it is not steady state measurement, we put the operators together, switch on the equipment and start measurements right away, for a period of say 6 hours, so it is not a steady state measurement.

The voltage applies tends to increase the temperature, so as I said the test is a basically a conductivity of the concrete, and it is correlation with chloride and permeability. Thus, any conducting material present in the sample will create a bias in the test, and causing the results to be higher. So, if there is more conductivity, i will be higher that is the current will be higher, and therefore, we will get results which would indicate that the coulombs are higher.

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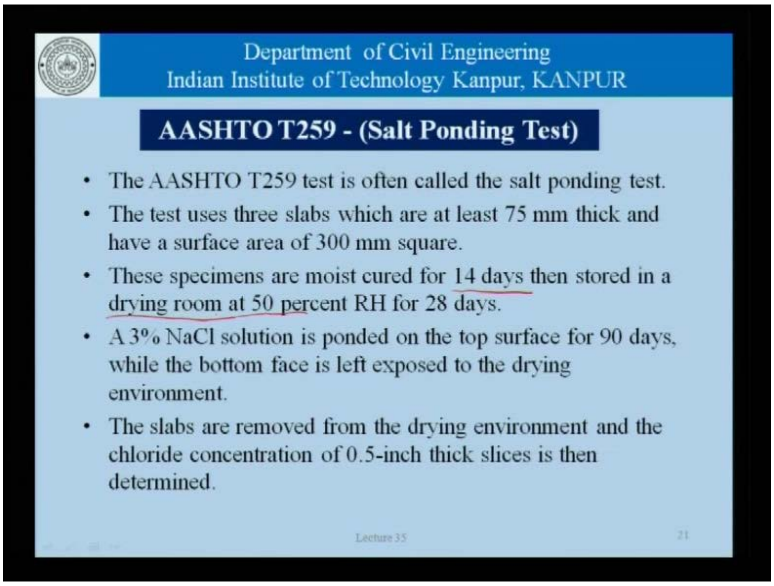

Another variation from the rapid chloride permeability test, is the so called salt ponding test, which has been standardized in AASHTO T259, the previous one was AASHTO T277. Now, in this test what is done is that three slabs having a certain area, having a certain minimum thickness, they are moist cured for 14 days is stored in drying room at 50 percent relative humanity for 28 days. And after this a 3 percent sodium chloride solution is ponded on the top surface, for a period of 90 days. While the bottom of faces left exposed to the drying environment, the slabs are removed from the drying environment and the concentration of chlorides in thick slices or in slices is determined.

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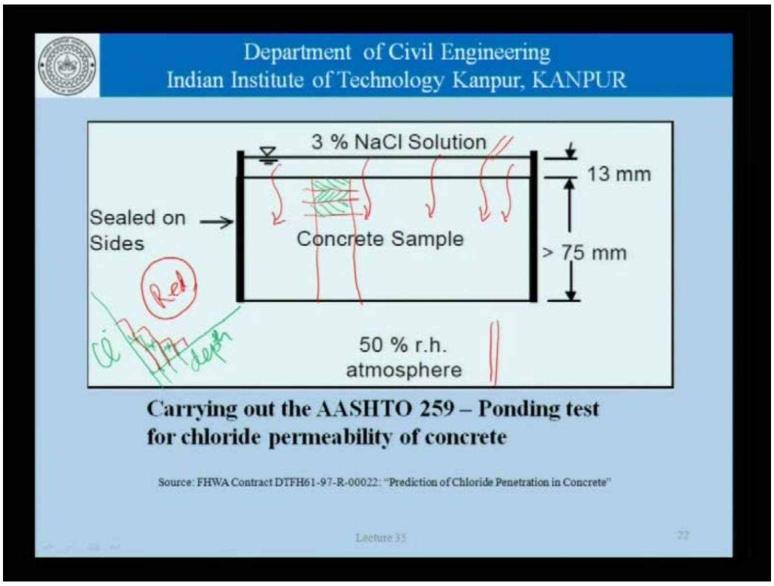

So, if we look at the diagrammatic representation of this test, what it does is we have a concrete sample which is sealed on the sides is exposed to a 50 percent relative humidity atmosphere or this end, ponded with 3 percent sodium chloride solution on the other. And we have the sodium chloride solution permeating into the concrete. and at the end of the 90 day period, we try to take a core out of this concrete specimen cut that into slices, and determine the chloride concentration in the different slices.

So, in this slice which is the closest to the surface, the concentrations are going to be higher and as we go deeper into the concrete the concentration will go down. So, effectively what we try to do is to try to determine what is the chloride and concentration, and how it varies with depth that is, we take slices from the surface inside and measure the chloride concentration. This chloride concentration can be measured by powdering the concrete, extracting the chlorides into an acid or water solution, and then carrying out a normal titration or an ions (( )) electrode method.

And finally, the evaluation on the basis of T259 is based on the chloride concentration in a given disk, or a diffusion coefficient which can be estimated, based on this distribution that we get, based on this profile. It is easy to understand that, if a concrete has to the distribution which is shown green here, compare to another concrete which has chloride concentrations like this. The red concrete has more porosity or higher chloride permeability, compare to the concrete which gives us the distribution that shown in green. So, basically through a ponding test what we try to do, is actually measure the chloride concentrations that are achieved within a concrete slab at the end of 90 day or a 3 month exposure period.

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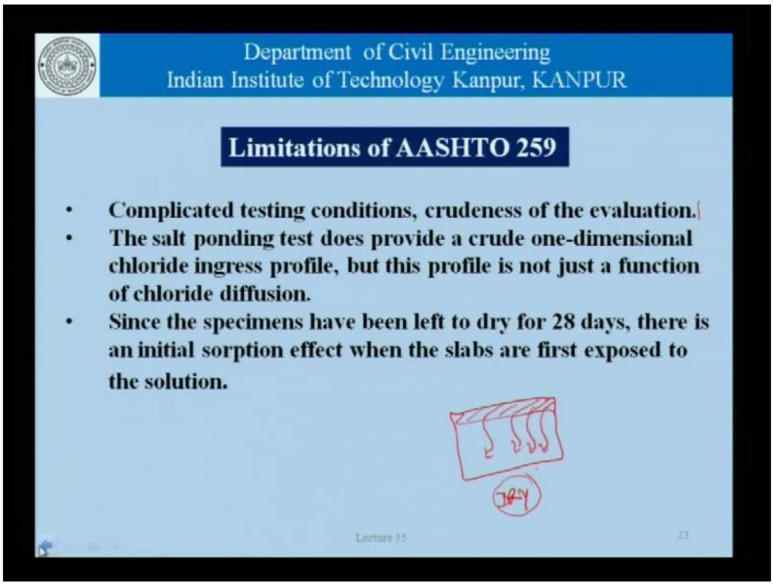

The limitations of this test obviously are it is a complicated testing condition, and the crudeness of the evaluation. The testing conditions are complicated, because even the specimen preparation and the pretreatment is quite complicated, preparation was slab, moist curing, dry curing at 50 percent RH for 28 days. And then having the concrete dry at one end, saturated with a sodium chloride solution on the other, promoting or driving the sodium chloride solution into concrete, on account of this gradient arising out of the dry weather.

Or the dry environment in this side of the concrete slab, it is quite a complicated testing condition. The solve ponding test does provide a crude, one dimensional provide ingress profile, but this profile is not a just function of the chloride diffusion. And since the specimens have been left to dry for 28 days, there is an initial sorption effect, when the slabs are first exposed to the solution. Because, there is a trying involved, because the specimens that are used in the tests are initially dry, so it is not only the chloride ions that move in, but also the water that moves into the concrete.

And that complicates the behavior, and that complicates any modeling that a scientist or an engineer to might like to do for this test, so all this contributes to the complicated testing conditions. And at the end of it we need to wait for a period of 90 days, before we can actually pronounce a judgment as to whether or not a concrete is acceptable. Of course, the merit of this test is the fact that, it is close to the actual exposure conditions of concrete, at least in marine environment we can say that yes, the concrete is going to be subjected to salt water.

Or immense in salt water in certain cases, and we would like to know how much of salt water penetrate, you would like to predict that but how much we can predict, on the basic of a 90 day test compare to the service life of a structure, which could be several tends of years that is a different question all together. Thus, as far as the 259 and the 277 are concerned, both of them are give us results as far as chloride permeability concerned; in one case the results are available and let say about 6 to 10 hours. Because, the actual test in 277 is for 6 hours, and if we give or take a couple of more hours for preparation and so on, the results are available very quickly. But, into the case of two five nine the results are available only after period of 3 months.

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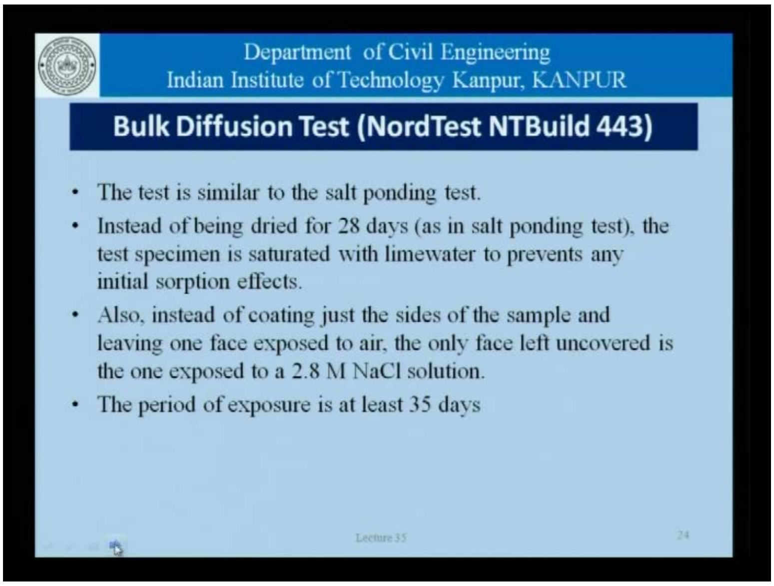

Continuing the discussion on chloride permeability, there is a bulk diffusion test, call the Node Test NTBuild 443, and this test is basically similar to the solve ponding test, except that instead of being dry for 28 days, the test is specimen is saturated with lying water, to prevent any initial option effect. And also instead of coating just the sides of the sample, and leaving one face exposed to air, the only face left uncovered is the one exposed to 2.8 M NaCl. So, instead of a 3 percent NaCl solution, we us a 2.8 M NaCl solution in this case, and the period of exposure is at least 35 days.

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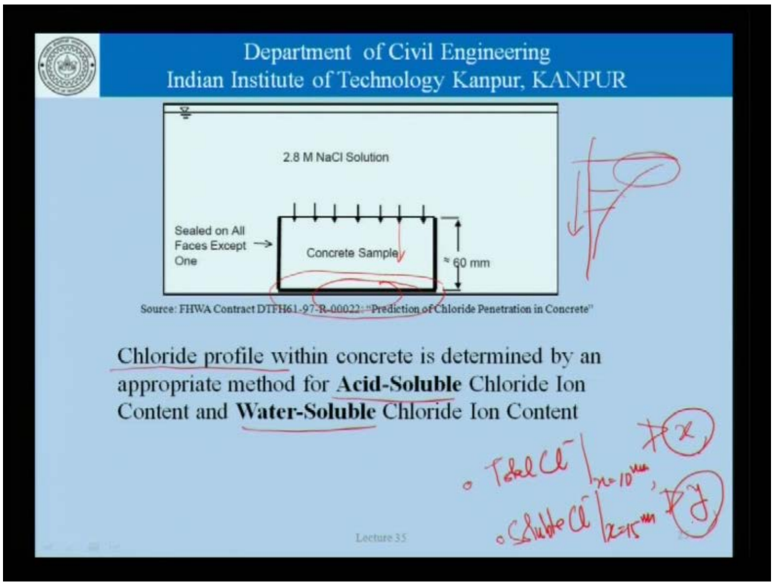

So, we can read more about the details of the tests, but the representation of the how the test is actually carried out. So, as against 259 where this space was open, and part of the reason for driving the chlorides into the concrete was the drying that was occurring on this face. In this case here the specimen saturated with lying water to get read of the sorption effects in a to get read of the sorption effect initially, and also ensure that the movement of chloride occurs only on account of diffusion.

The initially the pore solution will be free of any chloride ions, once these expression pores to 2.8 M NaCl, the chloride ions would begin to move into the concrete. And again we would get a chloride profile, which will look like something like this, where the surface will have a large amount of chlorides as we go deeper into the specimen, the concentrations would become smaller. If we want to compare the chloride concentrations in this test, with respect to those obtained in the 259, it is difficult to say, but on the face of it can be said that they are likely to be lower.

For the simple reason that the period of exposure here is lower, we are just talking for 35 day, test compare to the 90 date ponding there, plus the fact that in the 259, we were driving the chlorides into the concrete along with water by having and evaporation or the drying of concrete at the other face, which is not happening here. In this case of course, he talk in terms of the asset soluble, and the water soluble chloride ion content, and the engineers can decide what kind of specification they want to write.

It can be said that well, we want the concrete when tested with this standard should not have an acid soluble chloride content, at a particular depth exceeding a certain number.

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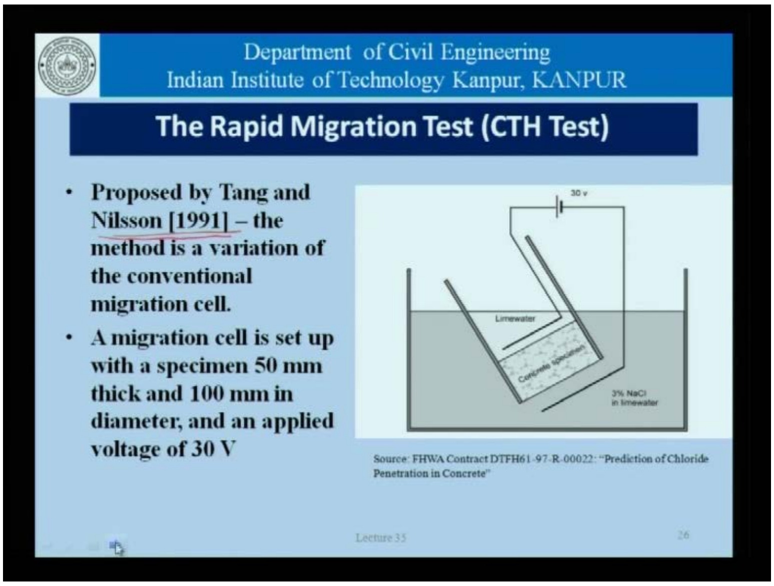

We can write a specification which sells that the total chlorides at x equal to 10 mm should not exceed some number, another engineer could say I would like to have a concrete where the soluble chlorides at x equal to 15 mm should not exceed a certain number. So, this is what we want to state by saying that we are getting into performance based is specifications, we are not talking only in terms of the, the strength of the concrete, but also in terms of the actual chloride permeability of concrete.

Now, what I wanted to point out with this slide was really the fact that, these tests some of them are as resend or as old whichever we looked it, from 1991 and so on, which means that we are looking at test which have been developed in just about the last 20, 25 years. And that means that they have a short history, and some of these tests are stilled in the research stage, some of them are being practiced, a part from the novelty of these tests, let us continue with our discussion on some other forms of chloride permeability testing.

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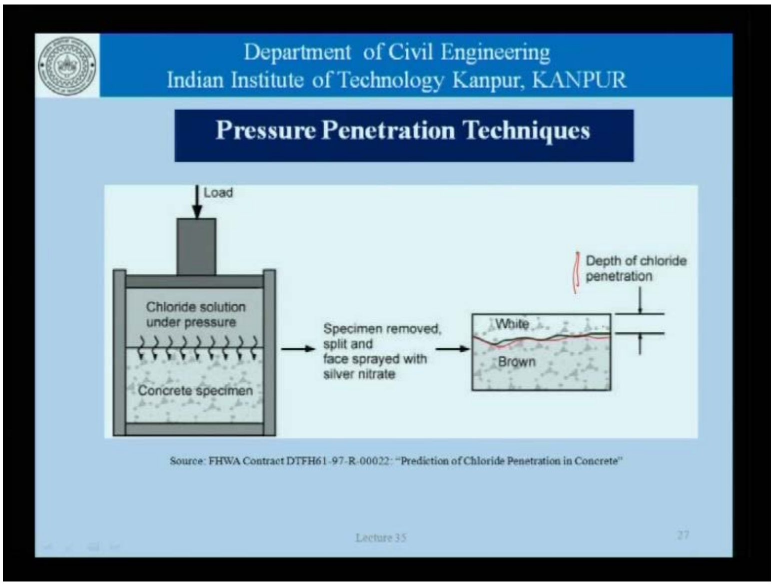

And here, we have the pressure penetration technique, where the chloride solution is pushed into the concrete under pressure. And the concrete specimen is drawn out and spread which silver nitrate, and we get a white deposit in areas where the chlorides have penetrated. So, in a manner of speaking this test is similar to that, we carry out when we measure the carbonation depth of course, in that case what we are trying to do is measured what area is calcium hydroxide has been lossed by spring phenolphthalein.

In this area, in this case we are trying to measure the areas where chlorides have reached within the concrete, and we do that by spring the solution of silver nitrate. And silver nitrate in the presence of chloride becomes silver chloride, and that is the white deposit or the white press that we see. So, well it is not easy to have a unique value of this step, because they profile of this white color will not be very regular, they will be aggregates within which will distort the profile further.

But, that is what an engineer has to decide, how to arrive at some kind of a measure of average depth of chloride penetration at the end of the test. Obviously things such as the is specimen preparation, the chloride concentration, the load to be applied, the duration for which it is to be a applied and so on, that have all to be standardized in this kind of testing.

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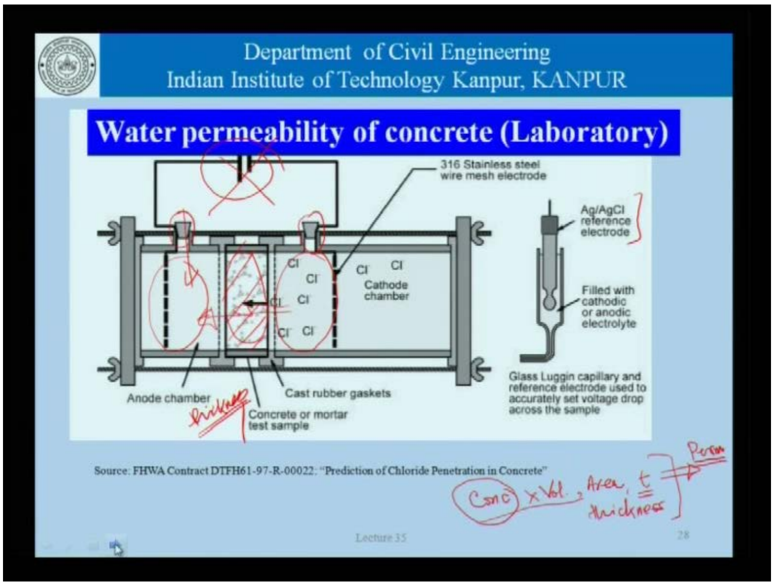

So, in principle what we have is a lot of methods use a setup, which is summarized here, we have a concrete specimen, on one side we have chloride reach environment, on the other side we have a environment which is not having chlorides to begin with. And then we try to push the chlorides through the concrete on to the other side, now if we apply a direct current here, the test becomes similar to or the test basically becomes the T277, that is rapid chloride permeability test.

If we do not apply any current externally it becomes of pure, diffusion sell kind of a setup, where we have to wait for the chlorides to emerge on to the other side, before we can talking in terms of the permeability, or the chloride formability of this concrete in between. When we are trying to low diffusion kind of a setup, without accelerating the chloride movement, obviously the test could go on for a very long time, unless we are able to reduce the thickness of the concrete which we are testing.

If we are able to get a very thins lies of concrete yes, then we can try to have results very quickly, but the problem of creating that thins likes of concrete, for a test like this would be in terms of creating or generating or causing cracks in the concrete. And therefore, that is the very, very severe limitation, in terms of the applicability of a pure diffusion sell kind of a test.

Of course, using these ports here, we could use a reference electrode and just deep the electrode here, at different points in time may be after a month, another month and so on.

And try to see whether or not, the chlorides have reach the other end of this chamber here, or what is the concentration; and once we know the concentration of chlorides in that chamber, and we know the volume of the water or whatever we are using in that chamber.

We know the area of the concrete through which the chlorides are diffusing, the time that is taking and the thickness of the concrete sample; this information is enough for us to be able to estimate or calculate the permeability of concrete, or the chloride formability of concrete.

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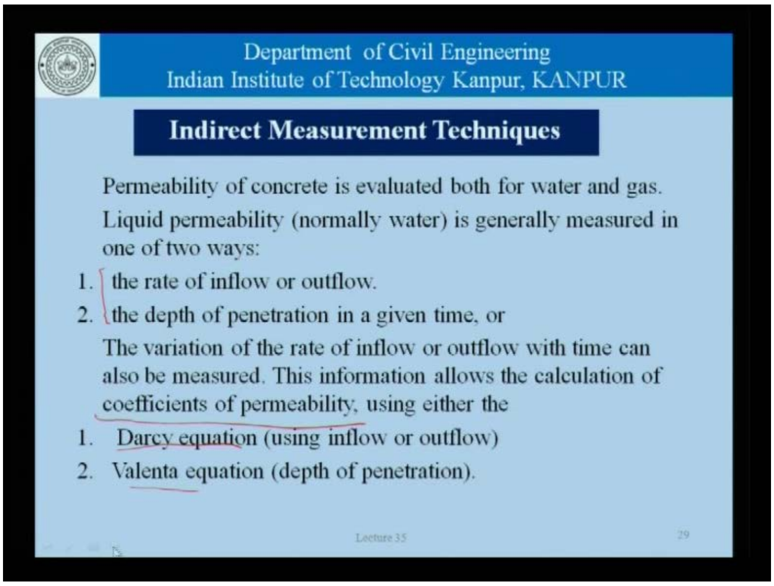

Now, with this kind of discussion on chloride permeability of concretes specimens or concrete, let us move towards the permeability of concrete for other material, such as water or gases. The liquid permeability water is generally of interest to us, we measuring two ways, one is by the rate of inflow or outflow, and that there is a by a depth of penetration at a given time, or in a given time.

We will talk about these two test a little bit in the next slide and so on, they helpers establish or estimate the coefficient of permeability of the concrete, based on either the Darcy's equation or the Valenta equation from the depth of penetration.

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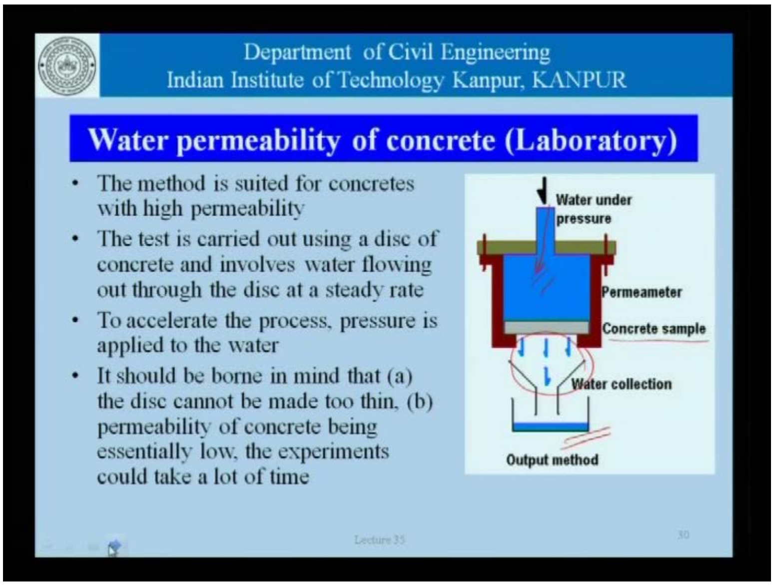

Now, let see what the water permeability of concrete the so called output method or the constant had method means. It means that first of all the method is suited for concretes which are highly permeable, that is a concrete sample which is place like this, and water is put here, and a pressure is applied, water actually flows out from the other side of the concrete sample. And we can collect a certain reasonable amount of water, in a reasonable time frame.

The test is carried out using a disc of concrete and involves water flowing through it at a steady rate, and to accelerate the process of course, pressure can be applied, but the pressure to be applied is limited by the fact that concrete cannot be subjected to bending. The, because the moment the concrete bends and being rigid tension, the concrete will simply break, we do not want the concrete to break, we want only the water move through the concrete, and not causing any flexure cracks in the concrete.

So, the pressure applied has to be limited, from that consideration and it should be bond in mind that the this cannot be made to thin, the permeability of concrete being essentially low, the experiments could take a fairly long time.

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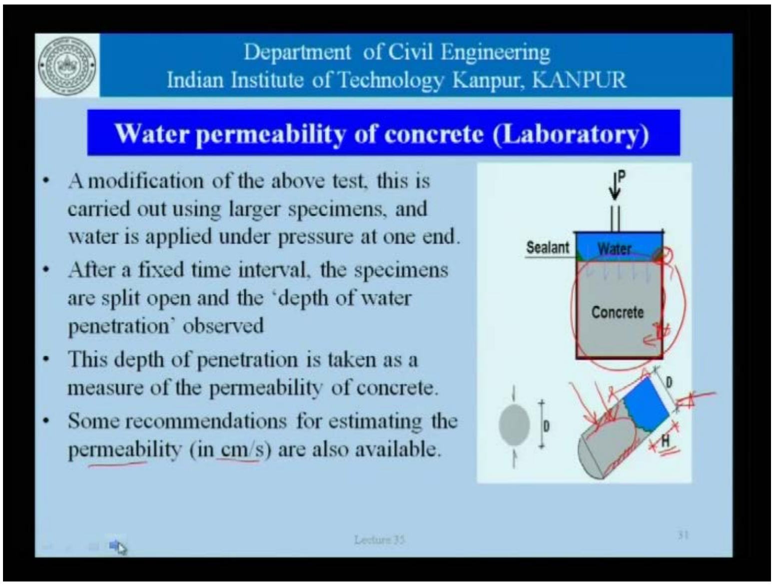

To address this we often carry out the test using the depth of penetration method in this case what we do, is that basically a modification of the above tests, and is carried out to using larger specimens, and what is applied at pressure at one end that does not change. What happens is that after fix time interval, they specimens are split open and the depth of water penetration is observed. So, we have a concrete cylinder or a concrete specimen here, we apply what are pressure on this, and at the end of certain fix time is split the cylinder, and try to see how much is the depth of penetration of water.

And this depth of penetration of water again is not so easy to measure, because of reasons arising from practical consideration, in terms of the presence of aggregates that non regularity of the pore structure and so on. At times if this sealing here at the edges is not very properly done, it is likely that the water can move along the edges, and penetrate into the concrete from the sides. In which case, instead of getting a profile like that in shown here, we may get a profile which is something like this, and this water coming from the sides; and that something which is highly undesirable as far as this test is concerned.

So, observing all these pre-corrosion is if we are able to carry out this test yes, the depth of penetration is representative of the water permeability of the concrete that we are testing. There are some recommendations which allows also to estimate the actual permeability, in terms of unit such as the centimeters per second or meters the per second based on this height age, or the depth of the penetration of water; at certain pressure that occurs over a certain period of time.

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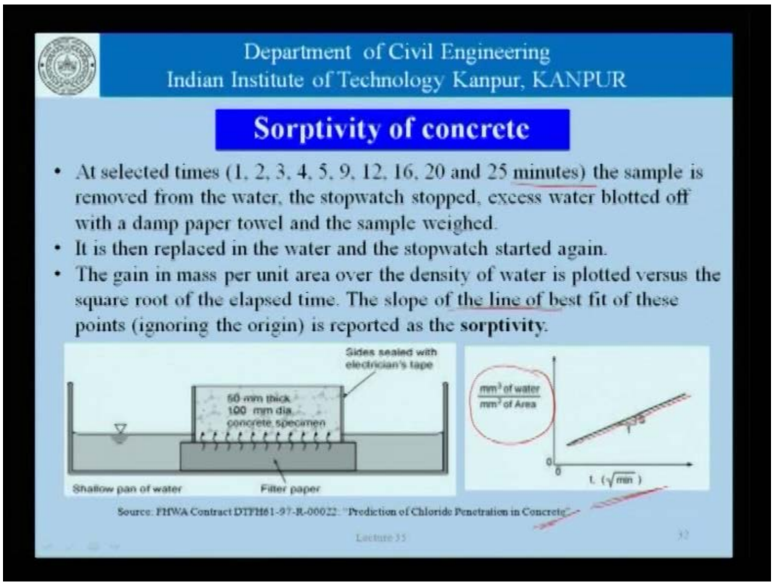

This here is the test for sorptivity of concrete that is a relatively new test which were a concrete specimen, which is 100 mm diameter, 50 mm thick is exposed to water with the filter paper raped on it. And it is selected intervals ranging from 1 to 25 minutes, the sample is removed from the water stopwatch is stopped, so we are watching or we are measuring the penetration of water, or they absorption of water by this is specimen, in a matter of minutes.

And this access water is blotted of with the damp paper towel, and the sample is weight and put back in the shallow pan of water, for the experiment to be continued, and what we able to record is the gain and mass per unit area over the density of water. This if it is plotted with square root of elapse time, the slop of this line gives us the sorptivity value. So, we really obtained the volume of water absorbed divided by the area of specimen, and if we plotted with respect to the root of time, we get a constant or a straight line and the slope of which is reported as the sorptivity value.

So, basically what we are saying is that we are looking for a measure of water absorption in the concrete, and this test can be completed fairly quickly, except for the time that is required to be prepared the specimen the first place. I must refer you to that this document, which is largely the spaces of our discussion today for water permeability as well as chloride permeability of concretes.

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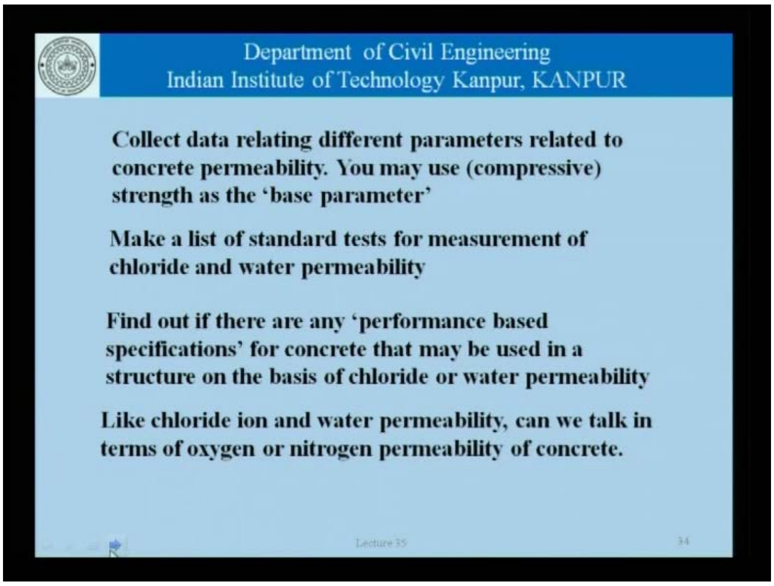

Now, before we close let us try to think of some questions that we want to take home, we could collect data relating to different parameters related to concrete permeability. We could use compressive strength as the base parameter, we could try to gets sorptivity values is reported in the literature with different concretes, we could get a RCPT values, we could get values from the T259 kind of test and so on, and try to see how they are related with each other.

We could make a list of the standard tests, for measurement of chloride and water permeability of course, we have mentioned some of the test in this discussion today. But, there are a lot of others, and I think that if we are motivated enough, and interested in the subject, you would look up the literature and come up with several other tests. We could find out, if there are any performance based is specifications for concrete that may be used in a structure on the basis of chloride or water permeability.

Like the examples that we talks about when we were discussing the results, from T277or T259 and so on. Like chloride ion and water permeability, can we talk in terms of oxygen or nitrogen permeability of concrete that is a question that I would leave with you to ponder about, thank you. Before the close the discussion, let me show you a diffusion cell kind of a setup, which can obviously modified to carry out test in accordance with ASTM C1202 are AASHTO 277.

This is one of the selves or the one of the reservoir with the hollow space here, which can be filled with either sodium hydroxide or water or a chloride solution. This is a wire mesh which is used to a apply current, if the current is being paced in between the two reservoir like this, so we have two reservoir an either side of concrete, there is a concrete block in between measuring about 90 to 100 mm diameter, 50 mm thick, and held together using bolds and so on.

If we want the apply current we can use wire measures like this to apply the current, the simple cell look something like this we have a reservoir on the other, there is a concrete disc in between, and the whole thing is helped together with bolts. So, if we want to regularly sample, whether the chlorides are coming on to the other side or not, whether they are traversing the concrete thickness or the or through the concrete or not what is the rate at which they are doing that.

We can always have probes through these holes that are there on the reservoirs, as for as T277 kind of test are concerned, we can use these wires which are connected to the measures that we saw, to impresses certain amount of current, across the two phases of concrete.